Assessing Traditional and Machine Learning Models for Inflation Forecasting in Emerging Economies with the Role of Foreign Exchange Reserves

Submitted by:
Stanzin Theytsal

Abstraction

This study compares the accuracy of traditional and machine learning models in predicting inflation in a growing economy (India) using monthly data from 2000 to 2024. Key macroeconomic indicators include the money supply, interest rates, exports, imports, exchange rates, foreign currency reserves, and the industrial production index (IIP). The comparison results demonstrate that machine learning models outperform traditional approaches by a large margin, with XGBoost emerging as the most accurate. Notably, their high feature value in ensemble models implies that increasing forecast accuracy necessitates foreign exchange reserves.

1. Overview

Financial stability, investment choices, and policymakers all depend on accurate inflation estimates. The conventional methods for predicting macroeconomic variables have been linear regression and ARIMA models. However, these methods usually fail to capture the complexity and nonlinearities of modern economic systems. Machine learning (ML) has emerged as a powerful alternative due to its ability to reveal hidden patterns and relationships.This study contributes to the literature in two ways:

1. It compares the forecast performance of machine learning models with conventional techniques using the same dataset.
2. It highlights the importance of foreign exchange reserves as a predictor of forecast accuracy.

2. Literature Review

2.1 Conventional Forecasting Models

Linear regression assumes a constant, linear relationship between inflation and its sources. ARIMA models simulate time series dynamics using residuals and historical values, however they suffer

from exogenous input issues and depend on stationarity assumptions. When data relationships are non-linear or affected by structural shifts, these models frequently exhibit poor performance.

2.2 Making Inflation Predictions with Machine Learning Because of their capacity to recognize intricate patterns, machine learning models like Random Forest, Gradient Boosting, Support Vector Machines (SVM), and Artificial Neural Networks (ANN) have shown remarkable success across a range of fields. According to recent research, machine learning algorithms—particularly those that use tree-based ensemble approaches—produce inflation forecasts that are more accurate (Mirza et al., 2024).

2.3 The Significance of Foreign Exchange Reserves

Forecasting inflation has historically resulted in the misuse of foreign exchange reserves. However, by stabilizing the exchange rate, lowering external vulnerability, and enhancing policy credibility, they play a critical role in controlling inflation. According to Mirza et al. (2024), both traditional and machine learning models' prediction accuracy is much increased by including foreign exchange reserves.

3. Information and Approach

3.1 Description of the Data

Monthly information was gathered for the following variables between January 2000 and December 2024:

Interest rates, the money supply, imports, exports,industrial production index (IIP),foreign exchange reserves and the exchange rate

The dependent variable is actual inflation (CPI).

3.2 Model Types

The study employs two traditional and five machine learning models:

- Traditional:

The results for traditional models were:

- Linear Regression (R^2 = -0.18, RMSE = 2.02)
- ARIMA (R^2 = -4.9311, RMSE = 2.5724)

- Machine Learning:

The result for machine learning models were

- Gradient Boosting (R^2 = 0.5755, RMSE = 1.598)
- Random Forest (R^2 = 0.5908, RMSE = 1.5696)
- ANN (R^2 = 0.3847, RMSE = 1.9247)
- SVM (R^2 = 0.6048, RMSE = 1.5425)
- XGBoost (R^2 = 0.6656, RMSE = 1.4189)

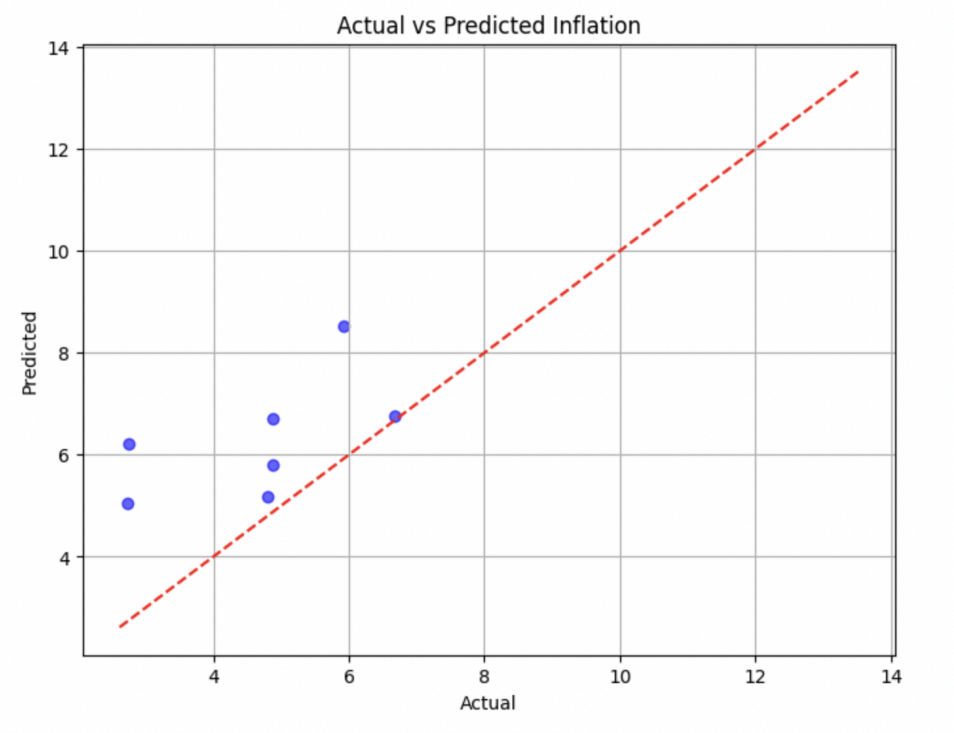
3.3 Evaluation Metrics

The models are evaluated using:The Root Mean Squared Error (RMSE) penalizes large errors.The percentage of variance that can be explained is displayed by the R2 score.

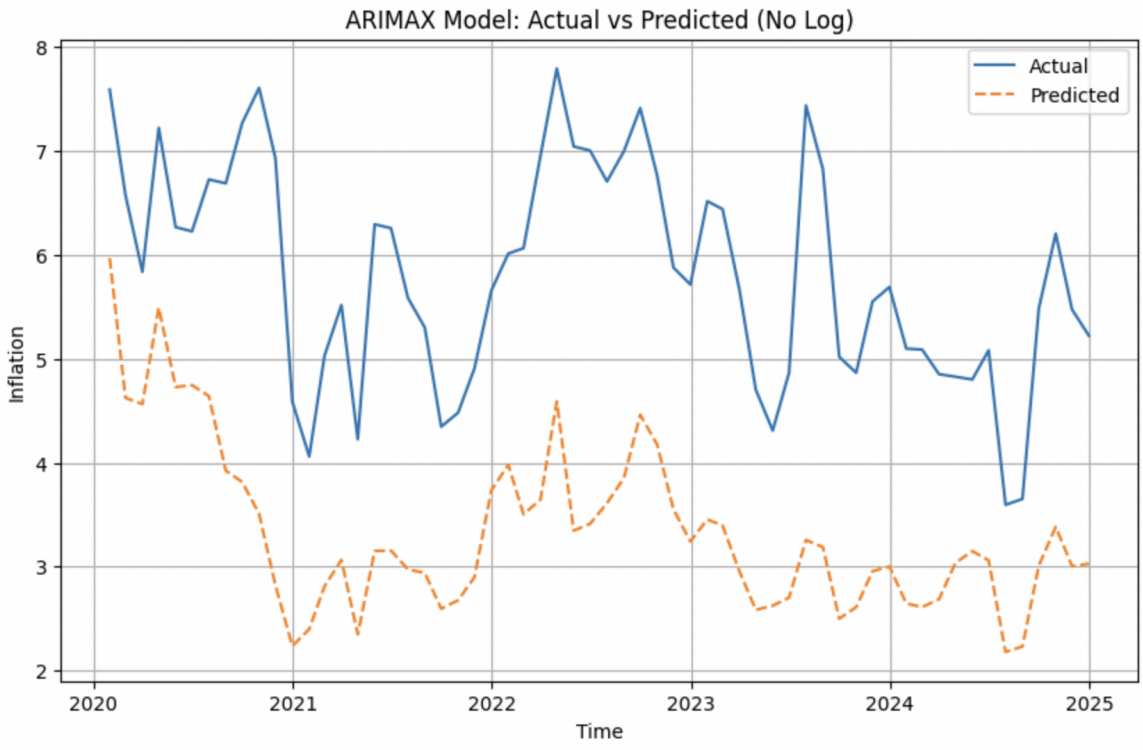
4. Results

4.1 Conventional Models Don't Work Well

Both Linear Regression and ARIMA performed poorly. The mean forecast outperformed linear regression with a negative R2. Despite being a time series method, the underlying dynamics could not be sufficiently captured by ARIMA.



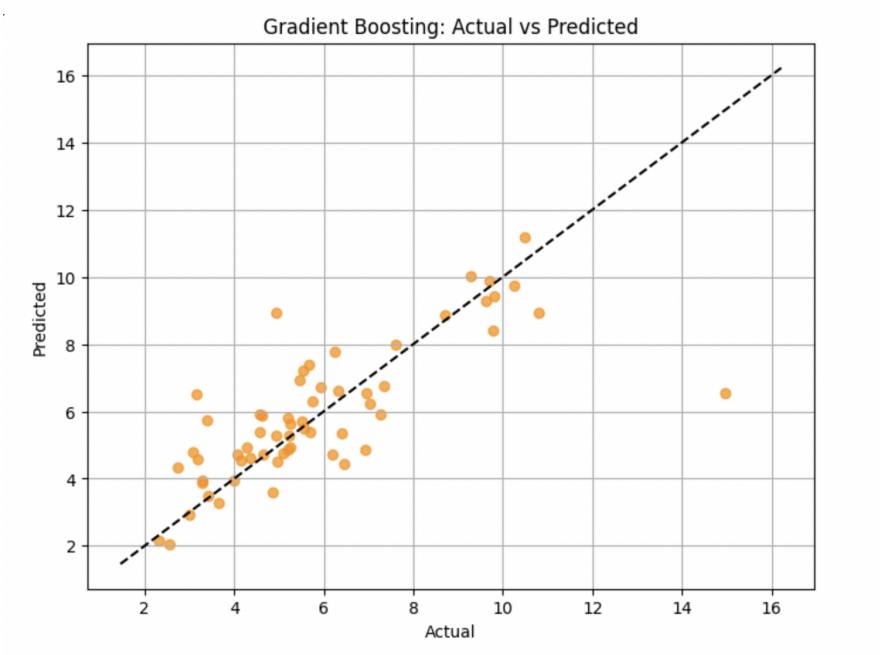
4.1.A Linear regression



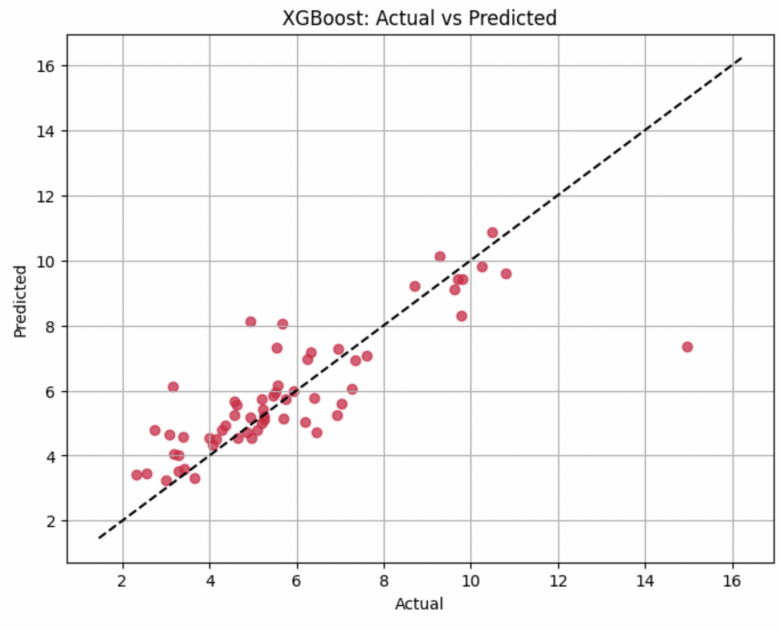
4.1.B ARIMA

4.2 Better Machine Learning Model Performance

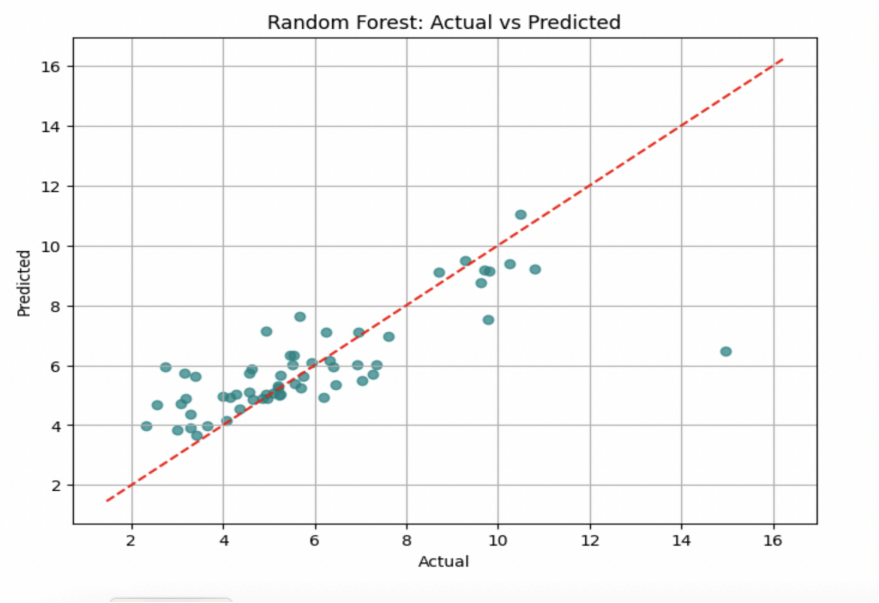
All ML models outperformed conventional ones, but SVM and XGBoost did the best. These findings support the increasing amount of studies showing that machine learning algorithms perform better than other techniques in predicting inflation, particularly when dealing with high-dimensional and non-linear data.



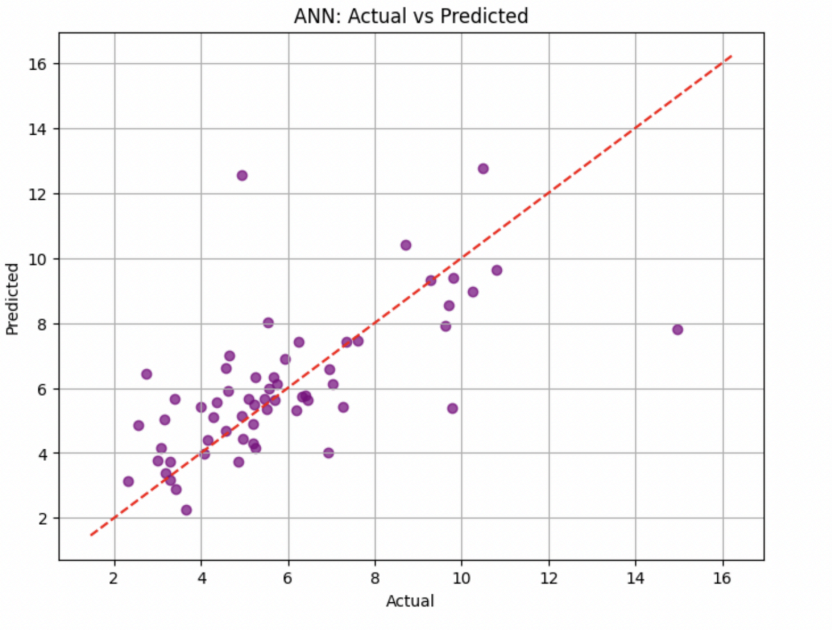
4.2.A Gradient boosting



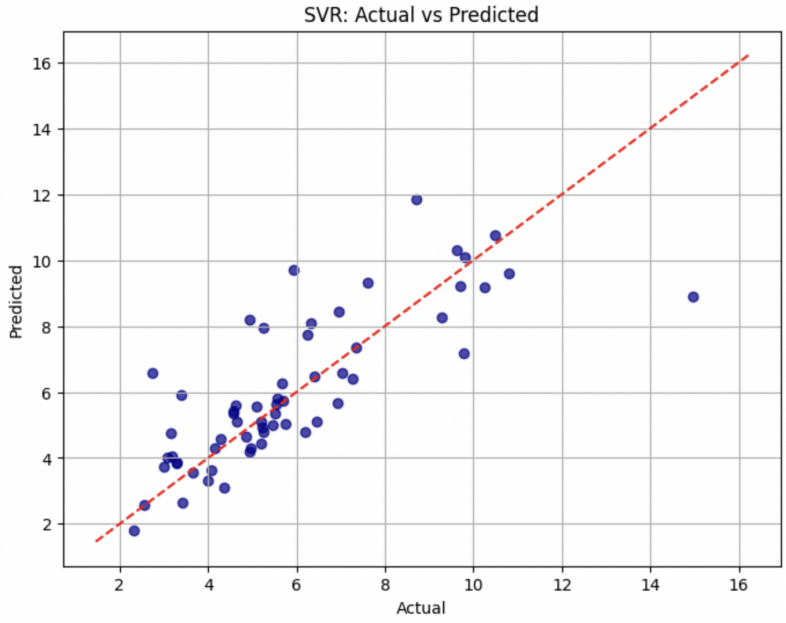
4.2.B Extreme gradient boosting



4.2.C Random forest



4.2.D ANN



4.2.E SVR

R^2 and RMSE COMPARISON

Model	Type	R^2	RMSE
Linear Regression	Traditional	-0.18	2.02
ARIMA	Traditional	-4.9311	2.5724
Gradient Boosting	Machine Learning	0.5755	1.598
Random Forest	Machine Learning	0.5908	1.5696
ANN	Machine Learning	0.3847	1.9247
SVM	Machine Learning	0.6048	1.5425
XGBoost	Machine Learning	0.6656	1.489

Traditional Models:

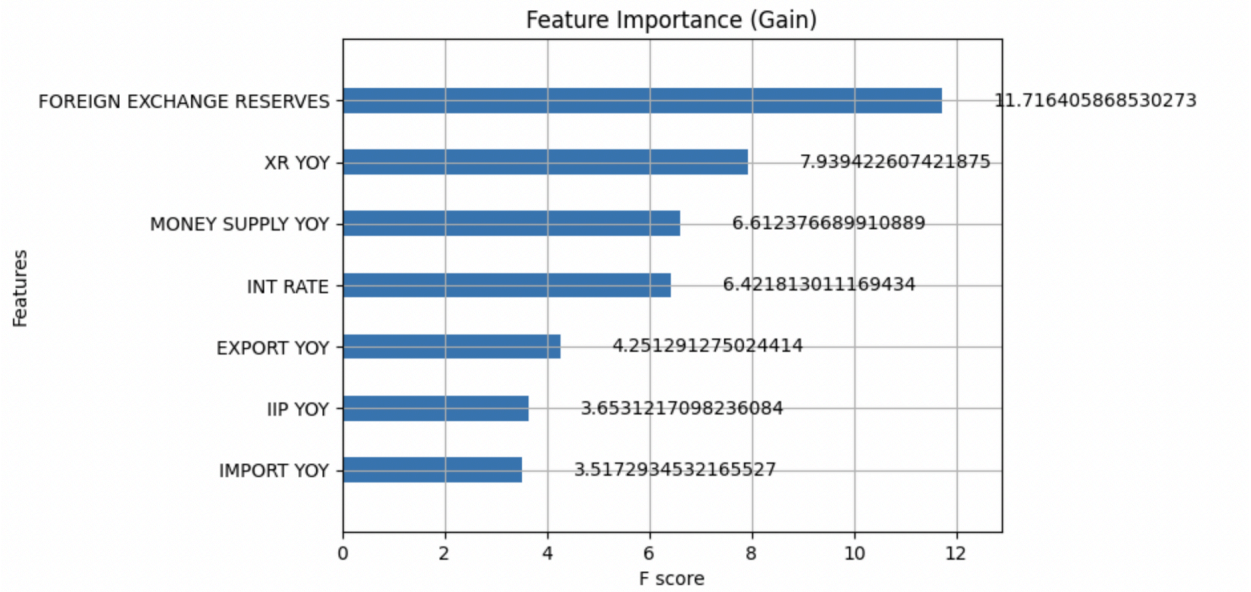
- Negative R^2 → Worse than mean prediction.
  High RMSE → Poor accuracy.

Machine Learning Models:

- Positive R^2 → Capture variance well.
- XGBoost is best (R^2 = 0.6656, RMSE = 1.4189).
- SVM and Random Forest also perform strongly, handling complex, non-linear patterns.

5. The Significance of Features and Foreign Exchange Reserves' Function

Based on feature importance assessments using Random Forest and XGBoost, foreign exchange reserves are the most significant predictor of inflation. This conclusion is in line with Mirza et al. (2024) and supports the notion that FX reserves stabilize inflation by reducing exchange rate volatility and moderating external shocks.



6. Conclusion and Policy Implications

This study confirms two significant findings:

1. Machine learning algorithms perform better than traditional methods in forecasting inflation. Machine learning models are more effective and capture intricate relationships and nonlinearities even when there are no strong assumptions about data distributions.

2. Foreign exchange reserves must be used in order to forecast inflation. Considering how important they are to many models, they probably provide important information about external stability and macroeconomic pressure.

Implications for Policy As a key macroeconomic indicator, foreign exchange reserves must to be included in all forecasting models used

by central banks and decision-makers.Inflation shocks can be better predicted and proactive monetary policy can be developed with the use of machine learning forecasting frameworks.Government analytics organizations ought to improve data infrastructure in order to facilitate the deployment of ML models in real time.

7. References

Mirza, N., Umar, M., Naqvi, B., & Rizvi, S. K. A. (2024). Predicting inflation in emerging economies: using machine learning and foreign exchange reserves to improve predictions. 94, 103238, International Review of Financial Analysis.